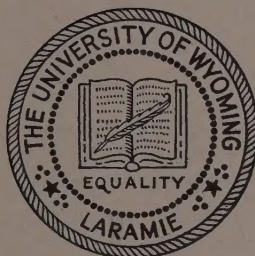


UNIVERSITY OF WYOMING
AGRICULTURAL
EXPERIMENT STATION



POTATO SEED-TREATMENT
STUDIES IN WYOMING

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POTATO SEED-TREATMENT STUDIES IN WYOMING 1932-1936*

G. H. STARR

INTRODUCTION

Common scab (*Actinomyces scabies* (Thax.) Güssow) and Rhizoctonia (*Rhizoctonia solani* Kuhn) are common potato troubles that annually take a large toll from potato growers in Wyoming. Rhizoctonia sometimes causes a reduction in the stand by cankering and killing young plants before they have emerged, or it may severely reduce yields of plants which have been attacked but not killed, resulting in the formation of small tubers usually close to the underground stem. This type of loss is not so important in Wyoming as in many other potato sections, because most of the potatoes are planted late when soil temperatures are favorable for plant growth. Rhizoctonia also reduces the number of marketable tubers by forming sclerotia on the surface of the potatoes. Scab causes much damage by reducing the grade of potatoes, making it necessary at times to sort out a high per cent of the tubers. Data on losses from these two diseases are not available for the state as a whole, over a period of years; however, the relative importance of these diseases may be seen, in a measure, from the rejections in certified potatoes made since 1929. During the past seven years, approximately 10,000 bushels of seed potatoes have been rejected annually because of too much disease or other defects. These rejections by years, given in per cent of Rhizoctonia and scab respectively, to the total rejections resulting from parasitic diseases, are as follows: 1929-30, 21.3 and 33.6; 1930-31, 11.7 and 70.6; 1931-32, 2.7 and 19.1; 1932-33, 31.9 and 33.4; 1933-34, 11.0 and 11.0; 1934-35, 17.0 and 0.0; and 1935-36, 4.0 and 8.1. These losses, when considered in the light of total potato production in Wyoming, emphasize their importance. During the years 1924-1935, inclusive, 2,063,168 bushels have been produced annually in the state with a maximum of 3,306,000 bushels pro-

*The writer is indebted to C. W. Roath, Superintendent of the Torrington State Farm and to A. L. Nelson, Superintendent of the Archer Station for their cooperation and help in caring for and in harvesting these plats at the respective stations.

duced in 1930. This crop has had an annual value of \$1,836,219.00 over the same period of years.

Losses from *Rhizoctonia* and scab are from two sources of infection: The seed piece, and the soil. The former can be controlled by seed treatments, while the latter cannot. Seed treatments have been in use for many years, and in Wyoming the following three have been used most extensively: Hot formaldehyde, corrosive sublimate or mercuric chloride, and Semesan Bel.

During the past few years, hot formaldehyde and corrosive sublimate have decreased in popularity while Semesan Bel has increased. This is, no doubt, due to the fact that the latter is easier and safer to use than is the hot treatment and requires less time than the corrosive sublimate treatment. At the time that this experimental work was begun, the Semesan Bel treatment had not given as good results as the other treatments and experiments were outlined to find, if possible, a treatment that would be safer to use than hot formaldehyde and one that would require less time than corrosive sublimate, yet would be as effective as either of the standard treatments. In addition, it was planned to test the relative effectiveness of treating materials in controlling diseases, together with their effect on yield, under both irrigated and dry-land conditions.

EXPERIMENTAL METHODS

Potato treatment tests were conducted during the 5-year period, 1932-1936, on the state farms at Torrington and Archer, and on the University Agronomy Farm at Laramie. Excepting at Torrington, data are not available for all years at all places because of such uncontrollable factors as excessive drought, hail, and psyllid yellows.

The soil type on the Laramie and Archer farms is very similar, it being a brown, bench, basic soil of a loam texture, while that on the Torrington farm is an alluvial terrace soil of a very fine sandy loam texture, derived from the Rosebud series. The pH of the soil in the different plats varied from 6.6 to 8.0. (Colorimetric.)

All plats were laid out with randomized replications, there being at least four replications to a plat. Each replication consisted of a row, in most cases 25 feet long, with 20 seed pieces uniformly spaced, although in one case, it was 50 feet long with 40 seed pieces. During the five years, the following treatments were used: (1) hot formaldehyde, (2) acid-formaldehyde, (3) formaldehyde dust, (4) sulfur dust, (5) mercuric chloride, (6) acid-mercury, (7) Mercurnol, and (8) Semesan Bel. All of these materials were not used each year at each station, because of lack of promise and because some were obtained after the experiments were started in 1932.

The seed used was grown either on the agronomy farm at Laramie, where scab is usually prevalent, or in the eastern part of the state by a certified seed grower, where occasionally *Rhizoctonia* is quite severe. The Bliss Triumph variety was used principally, although Cobblers were used to a lesser degree. The seed planted was either heavily scabbed or bore many sclerotia of *Rhizoctonia*. In some cases, healthy seed was treated with the various materials for comparison with the diseased lots. Non-treated lots or checks were used in all tests.

All lots of seed for the three farms were treated at the same time and in the same treatment-solutions, so that the manner of treatment would be comparable. All of the seed was treated before cutting, except where a dust was used, in which case, it was applied after cutting while the cut surfaces were still moist. With the exception of that planted in 1936, none of the seed was pre-sprinkled before treating.

Each treating material was used as follows:

(1) Hot formaldehyde—1 pint of formaldehyde to 15 gallons of water. In 1932, 1933, and 1934 tubers were treated for three minutes at 120° F., and in 1935 and 1936, at 122°-124° F., for a period of three minutes. They were then covered with wet burlap sacks for from one to two hours to prevent the fumes from escaping too rapidly.

(2) Acid-formaldehyde—1 per cent concentrated hydrochloric acid in formaldehyde solution (1 pint to 15 gallons of water). In 1932, 1933, and 1934, hydrochloric acid was used

and in 1935 and 1936, commercial hydrochloric or muriatic acid was used.

(3) Formaldehyde dust—freshly cut tubers rolled in dust in a container until well coated. In 1932, fresh dust was used; in 1933 and 1934 the same material was used as in 1932. New dust was used in 1935 and none used in 1936.

(4) Sulfur dust—inoculated sulfur was used to coat the surface of seed pieces as in the formaldehyde dust treatment. This treatment was tested only in 1934 and 1935. Fresh dust was used each year.

(5) Mercuric chloride (corrosive sublimate)—standard solution, 1:1000 or approximately at the rate of 4 ounces of mercuric chloride to 30 gallons of water, cold treatment. In 1932, 1933, and 1934, used in two-hour treatment; in 1935 and 1936, one and one-half hours.

(6) Acid-mercury—6 ounces mercuric chloride, 1 quart hydrochloric acid to 25 gallons water, 10-minute treatment.

(7) Mercurnol—according to directions, 10-minute treatment.

(8) Semesan Bel—1932 and 1933, approximately one-half minute dip; 1934, 1935, and 1936, New Improved Semesan Bel used, 1-minute treatment.

Each year the plats were planted as near the same time as possible. Some were planted with hand planters and some with a regular horse-drawn planter.

The plats were cultivated in the usual manner by workmen on the three farms. At Torrington and Laramie they were irrigated in the regular manner as uniformly as possible.

The Torrington plat was divided crosswise into four sections during 1933, 1934, 1935, and 1936, and each section was irrigated with different numbers of applications of water. One section was watered at weekly intervals during the growing season; one was watered weekly until small tubers had formed, then left dry the remainder of the season; one was left dry until small tubers had formed, then irrigated the remainder of the season at weekly intervals. The object in having such combinations of irrigation applications was to determine if moisture was an influencing factor

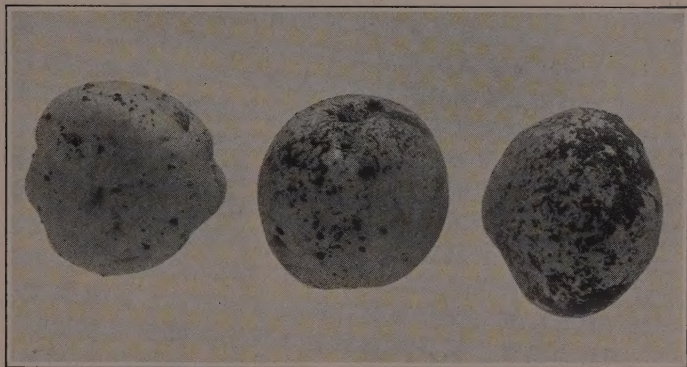


Figure 1. Potato tubers showing sclerotia of *Rhizoctonia* on their surface. These three degrees of severity were used as a basis to differentiate the three classes of *Rhizoctonia*, i.e. slight, medium and heavy, into which the potatoes were divided for disease readings.

for the development of scab and *Rhizoctonia* and, if so, if the time of application was important.

In one year, additional plantings were made to determine the amount of *Rhizoctonia* lesions on the plants. These plants were examined and are classified according to the severity of the lesions. However, except with badly infected seed, this type of infection was not very prevalent and was not investigated in detail for all experiments.

About October 1, the plats were harvested, in most cases, by hand, and the tubers were placed in burlap bags having numbers to indicate the row. The name of the treatment was purposely omitted to eliminate the possibility of biased judgment in the check-up. Each lot was weighed and subdivided into four groups depending upon the prevalence of scab on the tubers. These smaller lots were then weighed and the tubers counted. They were similarly divided for the presence of *Rhizoctonia*. For both diseases the following groupings were used: (1) healthy, (2) slight, (3) medium, and (4) heavy infection. Figures 1 and 2 show tubers representing these different degrees of infection with scab and *Rhizoctonia*. It was estimated that the tubers in the slight class would average approximately 5 per cent of the surface covered with scab; the

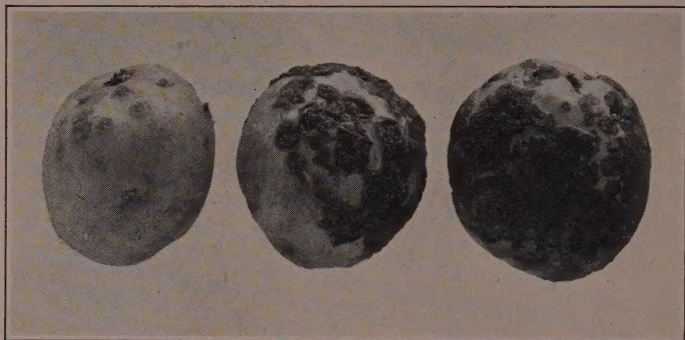


Figure 2. Potato tubers showing scab on their surface. These three degrees of severity were used as a basis to differentiate the three classes of scab, i.e. slight, medium, and heavy, into which the potatoes were divided for disease readings.

medium class 40 per cent, and the heavy class 75 per cent of the surface. The *Rhizoctonia* groups were divided on the basis that slight=1, medium=2, and heavy=3. In most cases, the weights were based on marketable tubers of 1½-inch minimum size. However, in the dry-land plats, this standard was not always used on account of the small size of the tubers. In such cases, 1 inch was used as the minimum size.

TREATMENT OF DATA

In order to compare the various lots for disease prevalence, an index number was calculated for both scab and *Rhizoctonia* in the following manner:

First, the percentage of the weight of tubers in each severity-class on the basis of the total weight was determined. The percentage of slight scab was multiplied by 5; medium scab, by 40; and heavy scab, by 75. The sum of these products was the index number for scab prevalence in each lot. The *Rhizoctonia* index number was found in a similar manner, except that the disease percentages in each class were multiplied by 1, 2, and 3, respectively, for the slight, medium, and heavy *Rhizoctonia* classes. Thus, the larger the index figure the heavier the disease infection.

These data, together with yield and percentage of disease-free tubers, were summarized according to the variance method as outlined by Snedecor (25), the value of z at the 5 per cent point being taken as the criterion for significance of the experiments. The various means are compared with the non-treated ones and with each other. In these comparisons the standard error of the difference between two means was determined. This number was then multiplied by the appropriate value for t , as given in Fisher's tables, to determine the value necessary for significance.

EXPERIMENTAL RESULTS

The results of the potato-treatment tests are summarized for each farm, each year, on the basis of stand, yield, scab prevalence, Rhizoctonia prevalence and percentage of disease-free tubers. Farther along, the information is recapitulated in summary, but not in tables, for all farms according to these and other headings.

(Table 1.) It may be seen that, in the majority of cases, the stands were slightly reduced by the treatments, although the yields show both increases and decreases over the controls (though not significant).

For the control of scab, formaldehyde treatments were best in lots from both healthy and scabby seed (differences significantly better than the non-treated lots) while the mercurials were least effective.

From the standpoint of Rhizoctonia control on both healthy and scabby seed, none of the treatments gave significant differences over no treatment.

In percentage of disease-free tubers, acid-mercury was best with healthy seed, followed by hot formaldehyde (both significant over controls), while with scabby seed, formaldehyde dust gave slightly better, but not significantly better results than the other treatments.

(Table 2.) The yields were very low because of a combination of drought and psyllid yellows and none of the yields were significantly different.

TABLE 1

Mean stands, yields, scab and Rhizoctonia prevalence, and percentages of disease-free tubers for various treatment-plots from healthy and scabby Bliss Triumph potatoes grown on the Torrington State Farm in 1932.

Kind of seed and treatment	% Stand	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease-free tubers	
		Mean*	Increase or decrease over control	Mean*	Increase or decrease over control	Mean*	Increase or decrease over control	Mean*	Increase or decrease over control
Healthy—no treatment.....	85	98.00	.....	7.39	.....	0.21	.....	26.25	.....
Healthy—hot formaldehyde.....	79	87.75	-10.25	3.02	-4.37	0.22	0.01	59.00	32.75
Healthy—formaldehyde dust.....	85	101.25	3.25	3.59	-3.80	0.16	-0.05	47.00	20.75
Healthy—Semesan Bel.....	80	109.75	11.75	5.89	-1.50	0.26	0.05	47.00	20.75
Healthy—acid-mercury.....	87	115.50	17.50	7.40	0.01	0.07	-0.14	29.00	2.75
Healthy—mercuric chloride.....	83	117.00	19.00	11.46	4.07	0.36	0.15	71.00	44.75
Scabby—no treatment.....	80	84.50	.....	8.45	.....	0.11	.....	41.25	.....
Scabby—hot formaldehyde.....	76	67.50	-17.00	4.06	-4.39	0.04	-0.07	42.00	0.75
Scabby—Semesan Bel.....	79	70.25	-14.25	9.57	1.12	0.19	0.08	31.00	-10.25
Scabby—formaldehyde dust.....	78	80.25	-4.25	3.23	-5.22	0.16	0.05	55.00	13.75
Scabby—acid-mercury.....	74	90.50	6.00	9.47	1.02	0.12	0.01	24.50	-16.75
Scabby—mercuric chloride.....	81	93.00	8.50	6.17	-2.28	0.04	-0.07	50.50	9.25
Difference required for significance.....	a	.....	31.38	.....	3.25	.....	0.18	.....	27.62

*Four replications.

†The minus quantities indicate less disease, the plus quantities more disease than the controls.

a—The F value was smaller than that necessary to give a P of .05.

TABLE 2

Mean yields, scab and Rhizoctonia prevalence, and percentages of disease-free tubers for various treatment-lots from both healthy and scabby Bliss Triumph potatoes grown at the Archer State Farm in 1932.

Kind of seed and treatment	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease-free tubers	
	Mean*	Increase or decrease over control	Mean*	Increase or decrease over control†	Mean*	Increase over control	Mean*	Increase or decrease over control
Healthy—no treatment.....	18.00	.....	0.05	.....	.....	none found	99.00	.....
Healthy—hot formaldehyde.....	9.75	-8.25	0.00	-0.05	.....	.....	100.00	1.00
Healthy—formaldehyde dust.....	17.00	-1.00	0.02	-0.03	.....	.....	99.75	0.75
Healthy—mercuric chloride.....	20.25	2.25	1.31	1.26	.....	.....	96.75	2.25
Healthy—acid-mercury.....	15.75	-2.25	0.66	0.61	.....	.....	96.75	2.25
Healthy—Semesan Bel.....	14.75	-3.25	0.28	0.23	.....	.....	97.25	1.75
Scabby—no treatment.....	12.25	.....	1.02	.....	.....	.....	90.00	.....
Scabby—hot formaldehyde.....	10.75	-1.50	0.16	-0.86	.....	.....	96.75	6.75
Scabby—formaldehyde dust.....	14.50	2.25	0.94	-0.08	.....	.....	96.25	6.25
Scabby—mercuric chloride.....	13.25	1.00	4.61	3.59	.....	.....	86.75	-3.25
Scabby—acid-mercury.....	17.25	5.00	0.12	-0.90	.....	.....	97.50	7.50
Scabby—Semesan Bel.....	11.25	-1.00	0.19	-0.83	.....	.....	96.25	6.25
Difference required for significance.....	.....	a	....	2.07	.....	.....	.....	4.99

*Four replications.

†The minus quantities indicate less disease, the plus quantities more disease than the controls.

a—Variation due to error was greater than that due to treatments therefore, data are not significant.

When used on healthy seed, hot formaldehyde and formaldehyde dust were slightly better than the other treatments for scab control (not significant). Hot formaldehyde, also, was one of the best in this respect in the scabby seed lots. Acid-mercury was high, while mercuric chloride was low (significantly so) in per cent of scab prevalence.

There were no *Rhizoctonia sclerotia* found in any of these lots.

In per cent of disease-free tubers, the differences between the treatments with healthy seed were not significantly different, while with the scabby seed, the hot formaldehyde, formaldehyde dust, acid-mercury and Semesan Bel treatments are all significantly above the non-treated lots.

(Table 3.) Most of the treatments applied to healthy seed reduced the yields, while they increased yields in all cases when used on scabby seed. The treatments varied considerably on *Rhizoctonia* lots of seed; acid-mercury, alone, increased the yield significantly over control lots.

There was very little scab on any of these lots, it being especially light on the tubers from the *Rhizoctonia* and healthy lots of seed (no significant difference).

The *Rhizoctonia* infection was also light, being entirely absent in the crop from the healthy seed. With lots of *Rhizoctonia* seed, acid-mercury and mercuric chloride were the only treatments that gave significant differences over the controls.

In per cent of disease-free tubers, where healthy or scabby seed was used, the differences between the treatments were very small. However, with *Rhizoctonia* lots of seed, acid-mercury and mercuric chloride were significantly better than the controls.

(Table 4.) Treatments on *Rhizoctonia* lots of seed increased the yield over non-treated seed, Semesan Bel and mercuric chloride being significantly high. With the scabby seed, the yields were neither significantly high nor low between treatments.

Lots of *Rhizoctonia* seed, treated with acid-mercury and mercuric chloride had a higher per cent of scab than the check (though not significant). In the scabby-seed lots, hot formaldehyde and

TABLE 3

Mean yields, scab and Rhizoctonia prevalence and percentages of disease-free tubers for the various treatment-plots from healthy, scabby, and Rhizoctonia-infected Bliss Triumph potatoes grown at the Torrington State Farm in 1933.

Kind of seed and treatment	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease-free tubers	
	Mean*	Increase or decrease over control	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control
Healthy—no treatment.....	131.50	.....	0.12	.....	0.00	.....	99.75	.....
Healthy—hot formaldehyde.....	90.50	-41.00	0.05	-0.07	0.00	0.00	99.00	-0.75
Healthy—acid-formaldehyde.....	89.00	-42.50	0.00	-0.12	0.00	0.00	100.00	0.25
Healthy—formaldehyde dust.....	88.00	-43.50	0.08	-0.04	0.00	0.00	98.00	-1.75
Healthy—acid-mercury.....	99.75	-31.75	0.02	-0.10	0.00	0.00	99.25	-0.50
Healthy—mercuric chloride.....	138.50	5.00	0.01	-0.11	0.00	0.00	99.75	0.00
Healthy—Semesan Bel.....	96.25	-35.50	0.18	0.06	0.09	0.00	96.00	-3.75
Rhizoctonia—no treatment.....	95.00	.....	0.00	.....	0.31	.....	69.75	.....
Rhizoctonia—hot formaldehyde.....	79.00	-16.00	0.00	0.00	0.36	0.05	63.50	-6.25
Rhizoctonia—acid-formaldehyde.....	82.00	-13.00	0.30	0.30	0.31	0.00	72.50	2.75
Rhizoctonia—formaldehyde dust.....	101.25	6.25	0.00	0.00	0.47	0.16	59.75	-10.00
Rhizoctonia—acid-mercury.....	161.50	66.50	0.05	0.05	0.03	-0.28	96.00	26.25
Rhizoctonia—mercuric chloride.....	96.00	1.00	0.30	0.30	0.03	-0.23	94.00	24.25
Rhizoctonia—Semesan Bel.....	85.25	-9.75	0.00	0.00	0.24	-0.07	76.75	7.00
Scabby—no treatment.....	77.75	.....	0.41	.....	0.06	.....	93.75	.....
Scabby—hot formaldehyde.....	85.25	7.50	0.01	-0.40	0.00	-0.06	99.00	5.25
Scabby—acid-formaldehyde.....	125.50	47.75	0.41	0.00	0.05	-0.01	93.75	0.00
Scabby—formaldehyde dust.....	120.00	42.25	0.77	0.36	0.00	-0.06	92.75	-1.00
Scabby—acid-mercury.....	88.25	10.50	0.20	-0.21	0.00	-0.06	97.25	3.50
Scabby—mercuric chloride.....	92.75	15.00	0.10	-0.31	0.01	-0.05	97.25	3.50
Scabby—Semesan Bel.....	103.25	25.50	0.53	0.12	0.01	-0.05	95.50	1.75
Difference required for significance.....	.....	51.02	....	0.46	....	0.10	.....	15.77

*Four replications.

†The minus quantities indicate less disease, the plus quantities more disease than the controls.

Table 4

Mean yields, scab, and Rhizoctonia prevalence, and percentages of disease-free tubers for the various treatment-plots from scabby and Rhizoctonia-infected Bliss Triumph potatoes grown at the Torrington State Farm in 1934.

Kind of seed and treatment	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease-free tubers	
	Mean*	Increase or decrease over control	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control
Healthy—no treatment.....	191.25	.....	1.40	.....	0.21	.....	78.00	.....
Rhizoctonia—no treatment.....	93.50	.....	1.32	.....	0.68	.....	43.25	.....
Rhizoctonia—mercuric chloride.....	173.00	79.50	2.20	0.88	0.43	-0.25	69.00	26.75
Rhizoctonia—acid-mercury.....	108.75	15.25	1.08	0.36	0.14	-0.54	87.25	44.00
Rhizoctonia—Somesan Iol.....	190.50	97.00	0.91	-0.41	0.35	-0.33	68.25	25.00
Scabby—no treatment.....	82.60	.....	2.63	.....	0.39	.....	65.50	.....
Scabby—hot formaldehyde.....	58.50	24.00	0.22	-2.41	0.03	-0.36	97.00	31.50
Scabby—acid-formaldehyde.....	91.50	9.00	0.36	-2.27	0.11	-0.28	91.50	20.00
Scabby—formaldehyde dust.....	93.00	10.50	3.72	1.00	0.60	0.27	43.50	-22.00
Scabby—sulfur dust.....	71.50	-11.00	3.37	0.74	0.31	-0.08	86.50	21.00
Scabby—mercuric chloride.....	121.75	39.25	1.13	-1.50	0.49	0.10	66.25	0.75
Scabby—acid-mercury.....	83.75	1.25	2.25	-0.38	0.13	-0.26	88.75	23.25
Scabby—Somesan Iol.....	91.50	9.00	2.00	-0.63	0.09	-0.30	92.00	26.50
Difference required for significance.....	.....	42.5	.....	a	.....	0.24	.....	20.23

*Four replications.

†The minus quantities indicate less disease, the plus quantities more disease than the controls.

a—Data were not analyzed as they were not significant.

acid-formaldehyde gave the best results in scab control, while formaldehyde dust and sulfur dust gave the poorest results (differences not significant).

From the standpoint of *Rhizoctonia* control, all treatments used on seed infected with *Rhizoctonia* were significantly better than the checks, acid-mercury being the best. On scabby seed, formaldehyde dust, sulfur dust, and mercuric chloride gave the poorest results, while hot formaldehyde, Semesan Bel, acid-formaldehyde, and acid-mercury gave the best results (significant over non-treated lots and the poorer treatments).

In per cent of disease-free tubers, each treatment of *Rhizoctonia* lots was significantly better than non-treated ones, acid-mercury being the best. All treatments of scabby seed were significantly better than the checks, except mercuric chloride and formaldehyde dust. The latter was significantly poorer. Hot formaldehyde gave the highest per cent of clean tubers.

(Table 5.) Yields were increased by the treatments of *Rhizoctonia* lots of seed, being significantly better with Semesan Bel and mercuric chloride. With the scabby lots, mercuric chloride alone was significantly better than the non-treated lots. On the other hand, hot formaldehyde, formaldehyde dust and sulfur dust had significantly lower yields than the non-treated lots.

In regard to scab prevalence, acid-mercury gave the best results of the treatments used on *Rhizoctonia* lots of seed. In the scabby lots, acid-formaldehyde was best, followed by hot formaldehyde, mercuric chloride, acid-mercury and Semesan Bel (all significant over non-treated lots).

In *Rhizoctonia* prevalence, acid-mercury on *Rhizoctonia* lots was best, but not significantly better than the control lots. With scabby seed, none of the treatments were significantly better than the non-treated lots, although one treatment, sulfur dust, was significantly poorer.

In the per cent of disease-free tubers, where *Rhizoctonia* seed was used, acid-mercury was best but not significantly better than

TABLE 5
Mean yields, scab and Rhizoctonia prevalence and percentages of disease-free tubers for the various treatment-plots from scabby and Rhizoctonia-infected Bliss Triumph potatoes grown at Archer Station in 1934.

Kind of seed and treatment	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease-free tubers	
	Mean*	Increase or decrease over control	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control
Healthy—no treatment.....	59.25	.....	1.77	.....	0.04	.....	84.25	.....
Rhizoctonia—no treatment.....	58.00	.....	1.02	.....	0.27	.....	69.50	.....
Rhizoctonia—mercuric chloride.....	66.75	8.75	2.30	.123	0.20	-0.07	63.00	-6.50
Rhizoctonia—acid-mercury.....	59.00	1.00	0.68	-0.34	0.14	-0.13	83.25	13.75
Rhizoctonia—Semesan Bel.....	76.25	18.25	2.05	1.03	0.32	0.05	62.50	-7.00
Scabby—no treatment.....	48.00	.....	12.60	.....	0.12	.....	42.75	.....
Scabby—hot formaldehyde.....	40.75	-7.25	2.26	-10.34	0.15	0.03	75.25	32.50
Scabby—acid-formaldehyde.....	48.50	0.50	0.71	-11.89	0.24	0.12	74.75	32.00
Scabby—formaldehyde dust.....	37.25	-10.75	9.81	-2.79	0.10	-0.02	49.25	6.50
Scabby—sulfur dust.....	39.00	-9.00	11.02	-1.58	0.39	0.27	43.00	0.25
Scabby—mercuric chloride.....	59.50	11.50	3.13	-9.47	0.11	-0.01	68.25	25.50
Scabby—acid-mercury.....	49.75	1.75	4.05	-8.55	0.03	-0.09	76.25	33.50
Scabby—Semesan Bel.....	51.00	3.00	7.17	-5.43	0.00	-0.12	72.25	29.50
Difference required for significance.....	.....	4.37	.....	4.99	....	0.18	.....	19.58

*Four replications.

†The minus quantities indicate less disease, the plus quantities more disease than the controls.

the controls or other treatments. With scabby seed, acid-mercury, hot formaldehyde, acid-formaldehyde, Semesan Bel and mercuric chloride gave significant increases over the controls but not over each other.

(Table 6.) Semesan Bel gave the best stand in the scabby lots, while formaldehyde dust gave the poorest. The latter also was poorest with the *Rhizoctonia*-treated lots, while acid-mercury and mercuric chloride were best.

Semesan Bel gave the highest yield of all treatments on scabby lots, while formaldehyde dust was lowest (significantly lower than the check). The latter was also significantly low in the *Rhizoctonia*-treated lots, while mercuric chloride was high (significantly above check).

In scab prevalence, all lots of treated scabby seed were significantly better than non-treated ones, acid-formaldehyde being best and acid-mercury second-best. Of the treatments on *Rhizoctonia*-seed, acid-mercury was best, though slightly better than no treatment.

Rhizoctonia prevalence was less for all treatments of scabby and *Rhizoctonia* seed than it was in the controls. None of the treatments, however, were significantly better than other treatments.

In per cent of disease-free tubers, all treatments of scabby and *Rhizoctonia*-infected seed were significantly better than the checks. In both the diseased lots, acid-mercury was slightly better than the other treatments.

(Table 7.) The stand was reduced somewhat by all of the treatments used on both diseased lots of seed. Acid-formaldehyde gave the lowest per cent stand while Semesan Bel gave the best stand when used on *Rhizoctonia* seed. Mercurnol gave the poorest stand of the scabby lots, while in the pre-sprinkled scabby lots it was high.

In general, yields were higher in pre-sprinkled treated lots than in treated lots not pre-sprinkled. Exclusive of pre-sprinkled lots, Semesan Bel gave the highest yield, followed closely by the

TABLE 6

Mean stands, yields, scab and *Rhizoctonia* prevalence and percentages of disease-free tubers for the various treatments lots from scabby tubers and *Rhizoctonia* infested Bliss Triumph potatoes grown at the Torrington State Farm in 1935.

Kind of seed and treatment	% Stand	Yield in bushels per acre		Scab Indexes		<i>Rhizoctonia</i> Indexes		% disease-free tubers	
		Mean ^a	Increase or decrease over control	Mean ^a	Increase or decrease over control	Mean ^a	Decrease under control	Mean ^a	Increase over control
CUMBER									
Healthy acid mercury	81	300.75	..	1.77	..	0.00	.....	90.50	.....
Scabby no treatment	88	243.00	..	7.08	..	0.35	.....	37.50	.....
Scabby hot formaldehyde	93	236.75	0.25	2.17	5.81	0.00	0.26	76.25	39.75
Scabby acid formaldehyde	81	291.25	18.75	0.20	-7.80	0.11	-0.24	80.25	48.75
Scabby formaldehyde dust	45	118.50	124.50	0.87	-7.11	0.01	-0.34	87.50	50.00
Scabby sulfur dust	88	238.50	4.50	1.70	0.28	0.02	0.33	79.25	41.75
Scabby mercuric chloride	70	208.75	25.75	1.43	0.55	0.00	-0.25	87.50	50.00
Scabby acid mercury	91	247.75	4.75	0.55	7.43	0.11	-0.24	88.75	61.25
Scabby Sequestrin Red	96	200.50	17.50	0.87	7.11	0.03	-0.32	81.75	44.25
BLISS TRIUMPH									
<i>Rhizoctonia</i> no treatment	90	251.00	..	0.13	..	0.50	.....	48.50	.....
<i>Rhizoctonia</i> acid formaldehyde	80	238.75	12.25	0.75	0.02	0.07	-0.40	82.50	34.00
<i>Rhizoctonia</i> formaldehyde dust	42	116.50	134.50	1.01	1.51	0.02	0.51	84.50	50.00
<i>Rhizoctonia</i> mercuric chloride	91	328.00	77.00	1.22	1.10	0.03	0.53	82.00	33.00
<i>Rhizoctonia</i> acid mercury	91	239.50	11.50	0.18	0.05	0.05	0.51	91.00	42.50
Difference required for significance	0	.....	77.04	..	2.40	.....	0.12	.....	14.47

^aFour replications.

^bThe minus quantities indicate less disease, the plus quantities more disease than the controls.

TABLE 7

Mean stands, yields, scab and Rhizoctonia prevalence and percentages of disease-free tubers for the various treatment lots from both healthy and Rhizoctonia infected Bliss Triumph and scabby Golder potatoes grown at the Torrington State Farm in 1936.

Kind of seed and treatment	% Stand	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease free tubers	
		Mean*	Increase or decrease over control	Mean*	Decrease under control†	Mean*	Increase or decrease over control†	Mean*	Increase over control
BLISS TRIUMPH									
Healthy—no treatment.....	91	126.60	.....	4.46	.....	0.12	.....	61.50	.....
Healthy—Mercural.....	71	103.25	-22.75	0.85	3.61	0.15	0.03	70.75	18.25
Rhizoctonia—no treatment.....	85	126.50	.....	5.70	.....	0.34	.....	49.25	.....
Rhizoctonia—hot formaldehyde.....	67	114.25	-12.25	0.30	5.46	0.20	-0.08	78.00	28.75
Rhizoctonia—acid formaldehyde.....	50	95.00	-31.50	0.89	4.87	0.14	-0.20	73.00	23.75
Rhizoctonia—mercural-chloride.....	69	114.25	12.25	0.18	5.58	0.05	-0.20	80.50	40.25
Rhizoctonia—Mercural.....	77	139.75	13.25	0.30	5.46	0.07	-0.27	86.00	36.75
Rhizoctonia—formal. hot.....	88	144.50	18.00	0.31	5.45	0.08	-0.26	85.75	30.00
Rhizoctonia—Mercural.....	78	181.75	55.25	1.12	4.64	0.07	-0.27	83.25	31.00
Rhizoctonia—acid formaldehyde.....	78	178.00	51.50	0.41	5.35	0.14	-0.20	82.25	33.00
GOLDER									
Scabby—no treatment.....	88	208.75	.....	2.06	.....	0.22	.....	65.50	.....
Scabby—hot formaldehyde.....	75	231.25	22.50	0.45	2.51	0.15	-0.07	81.50	16.00
Scabby—acid formaldehyde.....	72	239.00	31.25	0.52	2.44	0.12	-0.10	85.75	20.25
Scabby—mercural-chloride.....	80	198.00	-20.75	1.40	1.59	0.18	-0.04	76.25	10.75
Scabby—Mercural.....	63	197.00	-11.75	1.32	1.54	0.18	-0.04	74.50	0.00
Scabby—formal. hot.....	73	241.75	5.00	0.90	2.09	0.12	-0.10	83.00	17.00
Scabby—hot formaldehyde.....	80	246.75	38.00	0.92	2.04	0.11	-0.11	81.75	10.25
Scabby—acid formaldehyde.....	74	198.75	-20.00	0.42	2.54	0.10	-0.12	86.00	20.50
Scabby—Mercural.....	85	232.00	23.25	0.13	2.83	0.16	-0.06	93.75	20.25
Difference required for significance.....	19	.....	54.00	.....	2.36	.....	0.14	.....	10.00

*Four replications.

†The minus quantities indicate less disease, the plus quantities more disease than the controls.

‡Pre-epithelial 48 hours previous to treatment.

Mercuriol treatment on Rhizoctonia seed lots. In the scabby lots, hot formaldehyde and acid-formaldehyde gave the best yields. However, none of the increases in yield were significant except in some of the pre-sprinkled treated lots.

Nearly all treatments gave significant benefits in scab control over non-treated lots of both scabby and Rhizoctonia-infected tubers. However, no treatment was significant over another.

From the standpoint of Rhizoctonia prevalence on both Rhizoctonia and scabby seed lots, all treatments gave benefits over non-treated ones. Rhizoctonia lots of seed, when treated with mercuric chloride, Mercuriol, Semesan Bel, and acid-formaldehyde gave the best control of Rhizoctonia. On similar seed lots, hot formaldehyde was significantly poorer than any of the other treatments in the control of Rhizoctonia. None of the treatments used on scabby seed were significantly different in their ability to control Rhizoctonia.

In the per cent of disease-free tubers all treatments, except Mercuriol, were significantly better than the controls. This one was almost significant. With Rhizoctonia-seed lots, acid-formaldehyde was significantly poorer than mercuric chloride, Mercuriol, and Semesan Bel.

(Table 8.) The largest increase in stand over check lots came from the use of acid-formaldehyde on scabby Cobbler seed. This treatment also gave the highest increase in yield over checks, though not significantly. Mercurials used on Rhizoctonia seed decreased yields somewhat but not significantly.

Mercuriol was significantly better in controlling scab on Rhizoctonia-infected seed than was mercuric chloride. However, it was not as good as acid-formaldehyde in controlling scab on scabby seed (significant difference).

In the control of Rhizoctonia on Rhizoctonia-infected seed, Mercuriol was equally as effective as mercuric chloride, but somewhat less effective than acid-formaldehyde in controlling it on scabby seed (difference not significant).

TABLE 8

Mean stands, yields, scab and Rhizoctonia prevalence and percentages of disease-free tubers for the various treatment-lots from scabby Cobbler and Rhizoctonia-infected Bliss Triumph potatoes grown at the Archer Station in 1936.

Kind of seed and treatment	% Stand	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease-free tubers	
		Mean*	Increase or decrease over control	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control†	Mean*	Increase over control
BLISS TRIUMPH									
Rhizoctonia—no treatment.....	84	36.50	.....	1.75	.....	0.43	.....	57.00	.....
Rhizoctonia—Mercuriol.....	83	29.00	-7.50	0.95	-0.80	0.15	-0.23	77.50	20.50
Rhizoctonia—mercuric chloride....	85	27.75	-8.75	4.58	2.83	0.15	-0.28	63.50	6.50
COBBLER									
Scabby—no treatment.....	73	42.00	.....	10.08	.....	0.17	.....	23.50	.....
Scabby—Mercuriol.....	70	46.50	4.50	6.46	-3.62	0.24	0.07	39.50	16.00
Scabby—acid-formaldehyde.....	93	47.50	5.50	1.89	-8.19	0.16	-0.01	55.70	32.20
Difference required for significance..	a	.....	11.23	.....	1.51	....	a	.....	16.32

*Four replication.

†The minus quantities indicate less disease, the plus quantities more disease than the controls.

a—The F value was smaller than that necessary to give a P of .05.

In the per cent of disease-free tubers, Mercurnol was almost significantly better than mercuric chloride when used on lots of *Rhizoctonia* seed. On scabby seed, it was not equal to acid-formaldehyde (difference significant).

(Tables 9 and 10.) No treatment was consistently high in per cent of stand in the different lots under dry and irrigated conditions.

Healthy Bliss Triumph seed, when treated, gave an increase in yield over non-treated seed in both irrigated and non-irrigated plats. Acid-mercury was significantly better than other treatments in increasing the yield in the irrigated plat.

Most of the treatments used on scabby seed gave some decrease in yield, but not significant, in both irrigated and non-irrigated plats. With healthy Cobbler seed the treatments gave both increases and decreases in yield in non-irrigated plats and all increases in irrigated plats (differences not significant).

On *Rhizoctonia* lots, acid-mercury gave better yields in both irrigated and non-irrigated plats than did Mercurnol (difference not significant).

Scab was quite severe in the irrigated plat where healthy Bliss Triumph seed had been treated, being considerably worse than the check.

Acid-mercury on healthy Bliss Triumph seed gave slight scab in the dry plat, while in the irrigated one it was quite severe.

All treatments on scabby seed in the dry plat were beneficial in reducing scab (differences significant or nearly so), while in the irrigated plats, hot formaldehyde alone was better than the controls. When used on a healthy Cobbler seed, acid-formaldehyde in the non-irrigated series and hot formaldehyde in the irrigated series gave the most freedom from scab. Mercurnol and Semesan Bel increased it even above the controls. With *Rhizoctonia* lots, acid-mercury was slightly, though not significantly, better than Mercurnol for scab control.

In both irrigated and non-irrigated plats, hot formaldehyde, Mercurnol and acid-mercury treatments on healthy Bliss Triumph

TABLE 9

Mean stands, yields, scab and Rhizoctonia prevalence, and percentages of disease-free tubers for the various treatment-plots from healthy and Rhizoctonia-infected Cobbler seed and healthy and scabby Bliss Triumph seed grown in non-irrigated plots at the Agronomy Farm, Laramie, in 1936.

Kind of seed and treatment	% Stand	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease-free tubers	
		Mean*	Increase or decrease over control	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control
BLISS TRIUMPH									
Healthy—no treatment.....	90	42.00	.....	0.27	.....	0.53	.....	49.25	.....
Healthy—hot formaldehyde.....	83	63.50	21.50	0.12	-0.15	0.18	-0.35	79.50	30.25
Healthy—Mercuriol.....	100	64.50	22.50	0.71	0.44	0.17	-0.36	76.25	27.00
Healthy—acid-mercury.....	93	69.50	27.50	0.00	-0.27	0.12	-0.41	88.50	39.25
Healthy—Semesan Bel.....	73	81.75	39.75	0.27	0.00	0.30	-0.23	70.25	21.00
Scabby—no treatment.....	93	115.00	.....	4.22	.....	0.24	.....	66.75	.....
Scabby—hot formaldehyde.....	90	90.75	-24.25	0.16	-4.06	0.09	-0.15	88.00	21.25
Scabby—Mercuriol.....	85	100.00	-15.00	0.96	-3.26	0.21	-0.03	73.75	7.00
Scabby—Semesan Bel.....	88	103.00	-12.00	1.94	-2.28	0.20	-0.04	79.50	12.75
COBBLER									
Healthy—no treatment.....	85	108.00	.....	3.13	.....	0.41	.....	48.50	.....
Healthy—hot formaldehyde.....	96	92.75	-15.25	0.44	-2.69	0.68	0.27	48.75	0.25
Healthy—acid-formaldehyde.....	95	120.00	12.00	0.24	-2.89	0.68	0.27	47.75	-0.75
Healthy—Mercuriol.....	90	70.50	-37.50	4.08	0.95	0.55	0.14	47.00	-1.50
Healthy—Semesan Bel.....	93	95.75	-12.25	3.78	0.65	0.56	0.15	62.50	14.00
Rhizoctonia—acid-mercury‡.....	88	101.00	.....	2.15	.....	0.43	.....	47.75	.....
Rhizoctonia—Mercuriol.....	80	84.50	-16.50	2.55	0.40	0.53	0.10	49.00	1.25
Difference required for significance.	a	.....	26.52	....	2.95	....	0.31	.....	15.75

*Four replications.

†The minus quantities indicate less disease, the plus quantities more disease than the controls.

‡No check-plot because of insufficient seed.

a—Variation due to error was greater than that due to treatment; therefore, data are not significant.

TABLE 10
Mean stands, yields, scab and Rhizoctonia prevalence, and percentages of disease-free tubers for the various treatment-plots from healthy and Rhizoctonia-infected Cobbler seed and healthy and scabby Bliss Triumph seed grown in irrigated plots at the Agronomy Farm, Laramie, in 1936.

Kind of seed and treatment	% Stand	Yield in bushels per acre		Scab indexes		Rhizoctonia indexes		% disease-free tubers	
		Mean*	Increase or decrease over control	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control†	Mean*	Increase or decrease over control
BLISS TRIUMPH									
Healthy—no treatment.....	98	149.25	.....	0.36	.....	0.56	.....	51.50	.....
Healthy—hot formaldehyde.....	93	192.50	43.25	1.41	1.05	0.33	-0.23	55.25	3.75
Healthy—Mercurool.....	93	170.00	20.75	1.66	1.30	0.25	-0.31	64.00	12.50
Healthy—acid-mercury.....	93	261.25	112.00	4.75	4.39	0.27	-0.29	38.75	-12.75
Healthy—Semesan Bel.....	90	175.50	26.25	1.07	0.71	0.69	0.13	53.50	2.00
Scabby—no treatment.....	90	257.00	.....	0.84	.....	0.20	.....	69.00	.....
Scabby—hot formaldehyde.....	95	281.25	24.25	0.45	-0.39	0.20	0.00	71.00	2.00
Scabby—Mercurool.....	90	256.00	-1.00	1.16	0.32	0.16	-0.04	72.13	3.13
Scabby—Semesan Bel.....	88	196.75	-60.25	1.70	0.86	0.18	-0.02	72.00	3.00
COBBLER									
Healthy—no treatment.....	100	232.00	.....	0.63	.....	0.62	.....	42.75	.....
Healthy—hot formaldehyde.....	98	239.25	7.25	0.30	-0.33	0.68	0.06	37.25	-5.50
Healthy—acid-formaldehyde.....	93	248.00	16.00	0.85	0.22	0.78	0.16	49.25	5.50
Healthy—Mercurool.....	88	237.00	5.00	2.08	1.45	0.50	-0.12	47.50	4.75
Healthy—Semesan Bel.....	100	255.00	23.00	1.89	1.26	0.64	0.02	35.00	-7.75
Rhizoctonia—acid-mercury†.....	90	246.00	.....	0.75	.....	0.58	.....	39.50	.....
Rhizoctonia—Mercurool.....	85	224.00	-22.00	0.81	0.06	0.81	0.23	19.75	-19.75
Difference required for significance.	a	.....	55.04	.....	1.38	.....	0.17	.....	9.76

*Four replications.

†The minus quantities indicate less disease.

‡No check-plot because of insufficient seed.

a—Variation due to error was greater than that due to treatment; therefore, data are not significant.



Figure 3. Potato tubers infected with blackleg (*Bacillus atrosepticus* van Hall). Uncut tuber shows infected sunken portions from exterior view. Cut tubers show different degrees of rot within.

seed gave significant benefits in the control of *Rhizoctonia*, while Semesan Bel was least effective. None of the treatments reduced it significantly over the checks when used on scabby seed. With healthy Cobbler seed, the treatments, in most cases, gave increases in the amount of *Rhizoctonia* on the tubers. In the *Rhizoctonia* lots, acid-mercury was also better for *Rhizoctonia* control than Mercurnol (difference significant in irrigated plats but not in non-irrigated).

In per cent of disease-free tubers, all treatments on healthy Bliss Triumph seed, except acid-mercury under irrigation, gave benefits over the controls. However, acid-mercury gave the best results of any treatment under dry conditions. When used on scabby seed, each treatment gave benefits over the control, although in only one case, hot formaldehyde under dry conditions, was the difference significant. Treated healthy Cobbler seed gave both increases and decreases in per cent of disease freedom over the non-treated lots (not significant). On *Rhizoctonia* lots, Mercurnol was slightly better than acid-mercury in the dry series but poorer in the irrigated series in the per cent of disease-free tubers.

It is generally recognized that seed treatments are of value in killing seed-borne disease organisms such as scab, *Rhizoctonia*, and surface blackleg (Figures 3 and 4). However they are not effec-



Figure 4. Potato plants infected with blackleg. Note the black, slimy discoloration on the lower portions of the stems and roots.

tive against *Fusarium* wilt, virus diseases, or similar diseases infecting the inner tissues of the tuber. It is generally agreed that such treatments are not effective when the soil is badly infested, although it has been reported that certain treatments do have a beneficial effect other than that of disease control.

EFFECT OF TREATMENTS ON STAND

It is claimed that some of the seed-treating materials give protection to the seed-piece, thus preventing tuber-rot and resulting in a better stand, or at least in a more uniform stand. White (27) stated that hot corrosive sublimate in immersions of 12 to 18 minutes resulted in a reduced number of sprouts per plant as well as stunted plants. He also mentioned that hot formaldehyde caused a delayed emergence of potato plants. Vaughan and Brann (26) reported that hot formaldehyde was losing in popularity in Wisconsin because the treatment was likely to be followed by a poor stand and subsequent smaller yield. Clayton (6) states that organic mercury compounds were effective against seed-piece decay while Goss and Werner (11) found that, as a whole, they were not. The latter workers also stated that there was little difference in the final stands with any of the treatments.

During the period 1932-1936, the writer used new short-time liquid treatments and dust treatments, as well as the standard treatments, so that in some cases, stands are considerably reduced.

The following table gives the resulting stand from the use of various treatments.

TABLE 11
Average Per Cent Stand Resulting from the Various Treating Materials When Used on Healthy, Rhizoctonia, and Scabby Seed for all Experiments.

Treatments	Number of tests and per cent of stand			
	Healthy seed	Rhizoctonia seed	Scabby seed	Average
Checks	(7)* 90.4	(3) 86.3	(6) 85.3	87.7
Hot formaldehyde	(5) 89.8	(1) 67.0	(5) 85.8	85.9
Formaldehyde dust	(1) 85.0	(1) 42.0	(2) 61.5	62.5
Acid-formaldehyde	(2) 94.0	(2) 69.5	(3) 83.0	82.3
Mercuric chloride	(1) 83.0	(3) 82.6	(3) 83.0	82.8
Acid-mercury	(3) 91.0	(3) 90.7	(2) 82.5	88.7
Mercurnol	(5) 88.4	(4) 81.2	(4) 77.0	82.7
Semesan Bel	(5) 87.2	(1) 88.0	(5) 84.8	86.2

*Four replications in each.

Only one treating material (acid-mercury) gave a higher average stand than the non-treated lots and this difference was only slight. In fact, it is doubtful if the average difference between any of the treatments is significant, except that of formaldehyde dust which is considerably below the others.

SIZE AND VIGOR OF PLANTS

The factor of size and vigor was not given attention in all plats but was recorded for certain plats in 1935 and 1936. In this case, the number of small, medium, and large plants was recorded. The small plants were given a value of 1, the medium a value of 2 and the large ones a value of 3. In this way an index figure was calculated thus giving a relative comparison for size of plants. Diseased plants such as ones affected with "hay wire"¹ were not counted against the treatment.

A summary of these data shows that the treatments, as an average of all plats, ranked in the following order: (1) acid-mercury, (2) non-treated, (3) mercuric chloride and Mercurnol, (4) hot formaldehyde and Semesan Bel, and (5) acid-formaldehyde. Although the differences between all the treatments were small, acid-mercury ranked slightly above the untreated plats and was more consistent in this regard than any of the other treatments.

From the standpoint of the general vigor of the plants, it was difficult to draw any definite conclusions because of variation in the results in different plats. Weighings were not made of the plant tops, but the vigor was determined by the observable differences in the appearance of the various row-treatments. Goss and Werner (11) found that, if anything, the vine growth was greatest where the stand was poorest, which would seem to be a logical relationship. In these experiments, hot formaldehyde was low from the standpoint of uniform-sized plants but was high in the general vigor of the plants, although not consistently so. In some plats, Mercurnol and Semesan Bel gave vigor to plants but these occurred less frequently than in the ones treated with hot formaldehyde.

¹An unfortunate term applied to a rather common potato trouble in this and adjacent states. This disease is similar to the Moron disease described in other places.

EFFECT OF TREATMENTS ON YIELD

Most treating materials give increased yields because they control disease on the tubers. However, some claims of increased yield are made even when the treatment is used on healthy seed. Cunningham (7) in New York stated that with Cobbler seed, yellow oxide of mercury gave significant increases in yield over the controls. Clayton (6) reported that organic mercury treatments tended to increase yields in trials in New York. However, this finding has not been borne out in other places. (3, 11.)

During the 5-year period that these tests were conducted, none of the treatments have increased yields significantly above the control plats in which healthy seed was used. However, when the seed was affected with *Rhizoctonia*, certain treatments, have, in all cases but one, significantly increased the yields above the controls. This occurred twice in the mercuric chloride lots, twice in the acid-mercury lots, once in the Semesan Bel lots and once each in pre-sprinkled lots treated with Mercurnol and with acid-formaldehyde. When scabby seed was used, one experiment only showed significant increases in yield over the controls by treatments. In this case the lots treated with acid-mercury were high. In a few others, the differences were almost significant. On the other hand, there were two cases in which the yields were significantly low, one in the formaldehyde dust lots and one in the Semesan Bel lots.

In order to get a relative comparison of yields for all treatments in all plats, the following method was used. The standard error was used as a basis. Increases over the non-treated, equalling that of the standard error or less, were given a value of 1, increases up to twice the standard error, a value of 2, etc. Decreases were treated in the same way except that they were given negative values. The average of these values for each treatment was used as a basis for the following yield rankings, from best to poorest: Mercuric chloride, acid-mercury, Semesan Bel, Mercurnol, acid-formaldehyde, hot formaldehyde and formaldehyde dust. The two latter treatments reduced yields below those of the checks, while the others increased them.

EFFECT OF TREATMENTS ON SCAB PREVALENCE

Because the reaction of the soil is generally alkaline, scab is quite widespread on potatoes in Wyoming, and treatments are commonly used for the purpose of controlling this disease.

Treating materials vary greatly in their ability to control scab; in fact, some of them appear to increase it (9). In general, hot formaldehyde has been considered the standard for scab treatment, although some workers report favorable results from the use of mercuric chloride (1) and the organic mercury compounds (17, 6).

In the experiments reported in this bulletin, no one treatment was consistently better than the others. When healthy seed was treated, in only one experiment was there a significant difference in scab prevalence between treated and non-treated lots. In this case, hot formaldehyde and formaldehyde dust were both significantly better, while mercuric chloride was significantly poorer than the controls. With *Rhizoctonia* lots of seed, there were only two cases where a treatment significantly reduced the scab prevalence below that of the control lots. In both instances those were the Mercurnol-treated lots. In the scabby-treated lots, the better treatments were significantly better, in nearly every case, in the reduction of scab below that of the control lots. Acid-formaldehyde was best in three cases, hot formaldehyde in two cases, and Mercurnol and formaldehyde dust one case each. Considering all treatments in all experiments, they may be rated, as explained for yield studies, in the following order for scab control: Acid-formaldehyde, hot formaldehyde, formaldehyde dust, acid-mercury, mercuric chloride, Mercurnol and Semesan Bel. All treatments ranked above the controls.



Figure 5. Stems of potato plants infected with *Rhizoctonia*. Note the lesions on the stems where the fungus has "eaten" into the plant.

EFFECT OF TREATMENTS ON RHIZOCTONIA

As before mentioned, losses from *Rhizoctonia* may result from two types of infection: Namely, lesions on the under-ground plant parts as shown in Figure 5, and sclerotia on the tubers, shown in Figure 1. Although the first type of loss is not as important in Wyoming as in some other states, it is quite prevalent in occasional years, especially in early plantings. Usually, it is not severe enough to completely girdle and kill the sprout, but it does cause considerable reduction in yield because of lesions of varying size on the under-ground plant stem, roots, and stolons. Clayton (6) reported that mercuric chloride was effective in reducing the amount of stem infection while Semesan Bel was less effective in doing so. Goss and Werner (11) found that hot formaldehyde was somewhat more effective than mercuric chloride in reducing stem infection.

At the Archer farm in 1935, the amount of stem infection was checked in four lots planted with healthy-treated seed (acid-mercury); Rhizoctonia, non-treated; Rhizoctonia, mercuric chloride lots; and Rhizoctonia acid-mercury lots, each replicated four times. The plants were divided into four classes according to the amount and severity of Rhizoctonia infection on the stems, i.e. healthy, slight, medium, and heavy. The percentage of plants was determined for each group as may be seen in Table 12.

TABLE 12.
Percentages of Healthy, Slightly Infected, Medium Infected, and Heavily Infected Plants by Rhizoctonia Resulting From Seed Treatments as Compared With Control Lots.

Treatments*	Per cent of Rhizoctonia infection by classes			
	Healthy	Slight	Medium	Heavy
Healthy seed—acid-mercury treated	75	18	6	..
Rhizoctonia seed—no treatment	15	24	34	26
Rhizoctonia seed—mercuric chloride	55	28	9	7
Rhizoctonia seed—acid-mercury	63	29	7	1

*Four replications each.

The plants from the healthy-treated seed had relatively little Rhizoctonia infection, which apparently was caused by organisms from the soil. The plants from non-treated Rhizoctonia seed were heavily infected, while the mercuric chloride lots were much less so, and the acid-mercury lots still less heavily infected.

Because of the scarcity of acid soils in the potato-growing areas, Rhizoctonia tuber-infection is not of great importance, although it is sometimes abundant in occasional years and in certain places. The sclerotia formed on tubers are ordinarily small but hard. The larger the sclerotia and the harder and more compact they are, the longer the treatment necessary to kill the fungus within. Muncie (18), in Michigan, stated that ordinarily a 30-minute treatment with mercuric chloride gave satisfactory results, but when the sclerotia are thick and compact the time must be extended to 1 to 1½ hours. Sanford and Marritt (22), working in Canada, found that the lethal period for the small, medium, and large sclerotia was about 60, 130, and 150 minutes, respectively,

when cold mercuric chloride solution was used at the strength of 1:834. When acid-mercury was used, (strength 1:500, plus 1 per cent hydrochloric acid) all small sclerotia were killed in 3 minutes and the medium size in 5 minutes. After 5 minutes, 8 per cent of the large sclerotia were still viable and 2 per cent after 13 minutes. Cold formaldehyde was much less effective in similar tests. Pre-sprinkling was found to be effective in these tests. This phase will be discussed more fully under a separate heading later on in the bulletin.

Treating materials vary greatly in their ability to control Rhizoctonia on the seed-piece. Mercuric chloride has long been considered a standard treatment and in most places it has given satisfactory results (5, 8, 13, 16, 12, 20, 23). In general, the organic mercury compounds have not given as good results as mercuric chloride, although in some places workers report very good results (6, 20).

In these experiments, where healthy-treated seed was used, there were only two cases (Mercurnol and acid-mercury) where treatments produced significantly less Rhizoctonia than the non-treated controls. In most cases where Rhizoctonia lots were used, the treatments were significantly better than the control lots. Of these treatments, mercuric chloride and acid-mercury gave the best results. In the scabby lots, most of the differences in Rhizoctonia prevalence, attributable to treatments, were not significant. However, in two cases the contrary was true, the best treatments being hot formaldehyde and mercuric chloride.

When all treatments in all plats were summarized for Rhizoctonia control as explained for yield and for scabby seed, they ranked in the following order: Acid-mercury, mercuric chloride, acid-formaldehyde, formaldehyde dust, Mercurnol, Semesan Bel, and hot formaldehyde, followed by the controls. Although the differences between some of the treatments were small, there were several instances when one treatment was significant over another. They are as follows: Mercurnol and acid-mercury over Semesan Bel; mercuric chloride, Mercurnol and Semesan Bel over hot formaldehyde; acid-mercury over mercuric chloride (2 cases); mercuric chloride and acid-mercury over all other treatments; and acid-mercury almost significant over Semesan Bel.

EFFECT OF TREATMENTS ON THE PER CENT OF DISEASE-FREE TUBERS

As the scab and Rhizoctonia index figures do not indicate what per cent of the tubers were visibly free from these diseases, it was thought advisable to calculate such data and incorporate it in the tables along with the other summarized material. Although a treating material may decrease the yield, it may increase the per cent of healthy tubers. With healthy lots of seed, no treatment was consistently best. In the Rhizoctonia lots, acid-mercury was best in 4 of the 6 plats and with scabby seed it was best in 3 of the 10 plats, equalling hot formaldehyde in this respect. In no case was any treatment significantly better than the next best treatment, although a few times it was significantly better than the poorer treatments. In most cases some or all of the treatments were significantly better than non-treated seed in the per cent of tubers free from disease. For all experiments, the treatments ranked in the following order (same basis for rank as used with yield, scab and Rhizoctonia studies) in per cent of disease-free tubers: Mercuric chloride, acid-formaldehyde, acid-mercury, Mercurnol, hot formaldehyde, Semesan Bel and formaldehyde dust. All of these treatments ranked well above the controls.

EFFECT OF PRE-SPRINKLING THE SEED PREVIOUS TO TREATING

Pre-sprinkling of potatoes 48 hours or more previous to administering the seed treatment is recommended by some workers (1, 19, 12), while by others it is not recommended (3, 11). Pre-sprinkling is probably of more importance with Rhizoctonia seed than with scabby seed and the size and consistency of the Rhizoctonia sclerotia are, no doubt, important considerations in the use of this practice. If the sclerotia are small and not too hard, the treating solution should penetrate through the sclerotia and kill the Rhizoctonia fungus within a short time. As previously mentioned, Sanford and Marritt (22) have shown that the size of sclerotia is of extreme importance in the length of treatment necessary to be effective. With three treating materials used on small (1.5×0.2 — 0.4 mm.), medium (2.5×0.5 — 0.7 mm.), and large (3.5×0.8 —

1.5 mm.) sclerotia, it was necessary to treat the large sclerotia approximately three times as long, and the medium sized ones twice as long as the small sclerotia in order to kill them.

In the present investigations, pre-sprinkling was tried in one year only, but with both *Rhizoctonia* and scabby seed treated with three compounds. In stand, the pre-sprinkled lots were all better than the ones not pre-sprinkled, the differences being small to large. In yield, the differences were about the same in proportion and, with one exception, in favor of the pre-sprinkled lots. In *Rhizoctonia* and scab prevalence none of the differences were significant, probably because of the fact that the length of treatment was sufficient to be effective where pre-sprinkling was not done. In percentage of disease-free seed, the differences were all in favor of pre-sprinkling but significant in one case only. Where heavily infected tubers are used for seed, pre-sprinkling previous to treating should render the treatment more efficient.

LIQUID VS. DUST TREATING COMPOUNDS

Although the liquid type of treatment is by far the most common in experimental tests, some investigators report favorable results with the dust type of treatment. Clayton (6) reported that organic mercury compounds caused seedlings to be more vigorous and out-yield those treated with mercuric chloride. He also mentioned that Claus (5) found that potatoes treated with *Uspulum* powder out-yielded untreated seed by 25 to 40 per cent. However, in the tests conducted here, it was not the purpose to test many dusts for their relative efficiency but principally to test formaldehyde dust more extensively, as it had given favorable results in preliminary tests in Wyoming. Inoculated sulfur dust was used also in 2-year tests. In general, dust treatments are more cumbersome to use and for that reason it is doubtful if they will ever be used extensively, unless a dust is found which is far superior to the liquid treatments.

In these investigations, formaldehyde dust was a little more effective for *Rhizoctonia* than for scab but ranked below other treatments in both respects. On the whole, both stands and yields were reduced by this treatment, although in a few plats they were fairly good.

It was thought that perhaps the results might vary with the age of the dust, as fresh dust, dust one year old, and dust two years old, was used in the different years. However, these results were not consistent. It may be noted that the largest decreases in yield and the largest increases in per cent of disease-free seed were obtained with freshly-opened cans of dust.

NEW SHORT-TIME TREATMENTS IN COMPARISON WITH THE STANDARD TREATMENTS

One of the chief purposes of this study was to find treatments for both scab and Rhizoctonia which would be easier and safer to administer than the hot formaldehyde and less time-consuming than the mercuric chloride treatments. The commercial grower who has a considerable quantity of potatoes to treat is gradually getting away from the standard treating materials, mercuric chloride and hot formaldehyde, not because they are not efficient in disease control, but largely because they are not as convenient as some others. This is well exemplified by a summary of the treatments used by the certified potato growers in Wyoming. Since 1929, both mercuric chloride and hot formaldehyde, in per cent of growers using these treatments, have declined. In 1929, of the growers using potato treatments, 70 per cent used hot formaldehyde and the remainder, mercuric chloride, while in 1936, 27 per cent used hot formaldehyde and 10 per cent used mercuric chloride. Conversely, in 1929 there was no Semesan Bel used by these same growers, although its use began in 1930, and in 1936 it was used by 38 per cent of the growers.

Acid-mercury was one of the newer materials that was tested over the 5-year period because of promising results in other places. Leach *et al.* (14), who developed and popularized the acid-mercury treatment in this country, reported favorable results in the control of Rhizoctonia in Minnesota. Raleigh and Bonde (21) working in Maine, found that for Rhizoctonia control, it compared favorably with mercuric chloride. Dippenaar (8) reported that acid-mercury in both 5- and 10-minute treatments, gave as good results against scab as mercuric chloride; however, it was more effective

against Rhizoctonia. Brown and Streets (4) stated that in Greenlee County, Arizona, the acid-mercury treatment, because of its effectiveness and convenience, has entirely replaced the older methods. It is also gaining in popularity over the cold corrosive sublimate treatment in Wisconsin (26).

During the present study acid-mercury was found to be as good, if not better than mercuric chloride in effectiveness against Rhizoctonia. Moreover, it was equally as good, if not better for scab control. From the standpoint of yield and percentage of disease-free seed, it was practically the same in effectiveness as mercuric chloride. Acid-mercury is as easy to use as mercuric chloride and above all is a time saver requiring only one-ninth, or less, as much time as mercuric chloride.

Mercuriol, the commercial acid-mercury compound, has been used in comparative tests with acid-mercury for only one year, and safe conclusions cannot be drawn on this basis. However, on the whole, *Mercuriol* was somewhat less effective than the acid-mercury prepared in the laboratory. From the standpoint of yields, acid-mercury was slightly to significantly better than *Mercuriol*. The significant differences were on irrigated plats. With respect to scab, the difference was questionable, although in one case *Mercuriol* was significantly better. Likewise, with Rhizoctonia prevalence the differences were small, although in one instance acid-mercury was significantly better. *Mercuriol*, however, does have the advantage of being prepared ready for use, except for dilution.

Semesan Bel. Although this is not a new treatment, it will be included in this discussion of short-time cold treatments. From previous citations, it may be seen that the organic mercury compounds have not been as effective for scab and Rhizoctonia control as some other treatments. However, according to some reports, they have increased yields even when used on healthy seed.

In the present studies, *Semesan Bel*-treated healthy seed was the high yielder in 3 of the 7 experiments. However, in no case was it significantly better than the next best treatment. With Rhizoctonia seed, it was best in 1 of the 4 trials and with scabby

seed, best in only 1 of the 9 trials. On the other hand, it was significantly low in one trial. In both Rhizoctonia and scab control, where the tubers were badly diseased, it was one of the least effective of the treatments used. However, it is convenient to use and if the potatoes to be treated are only slightly diseased, it probably will give satisfactory results.

Acid-formaldehyde. This treatment, although not used commercially, was tested to determine its value for scab control, in particular. From the standpoint of yield, it was somewhat better than hot formaldehyde, it being best of all treatments in 3 of the 12 trials as compared with 1 of 20 for hot formaldehyde. For scab control, it was as good, if not better than hot formaldehyde, although less effective than some of the other treatments. In percentage of disease-free seed, it was one of the best treatments used.

THE RELATION OF MOISTURE TO SCAB PREVALENCE

There has been much disagreement in the literature as to the rôle of moisture in scab prevalence. There will be no attempt in this study to summarize this material, but mention will be made of a few citations dealing with moisture and treatments. Some reasons for this disagreement may be that more than one species of *Actinomyces* is involved (15) and that many factors may be involved in this relationship. Frutchey and Muncie (9) state that under low soil-moisture conditions (20 to 35 per cent) the presence of mercurials may increase the relative proportion of *Actinomyces* in the soil, and that under conditions of more abundant moisture the *Actinomyces* may become less numerous. They further state that small amounts of mercurials in the soil solution, though not affecting *Actinomyces scabies*, did inhibit growth of the normally soil-inhibiting bacteria and fungi and allowed the scab organism to develop more rapidly. Dippenaar (8) found in his studies that scab development was greatest at 40 per cent of the moisture-holding capacity of the soil; that little or no scab developed at or above 70 per cent, and at 55 per cent or below, few or no tubers were free from scab.

In the present studies, portions of the plats of potatoes at Torrington were watered differently for a 4-year period. This was done to determine the effect of moisture on scab prevalence and and to determine the effect of these applications in the first half and second half of the season. Scab prevalence was studied on healthy seed and scabby seed check plats, as well as on the total treatments for the four irrigation series. In the combined treatment plats the scab differences were not significant between the irrigation series, although scab was more prevalent in the non-irrigated series.

During one year, 1935, in both healthy and scabby check plats, the differences in scab were very significantly in favor of the dry plats. That year also, the irrigated plats received eight applications of water, the largest number given any of these plats during the years the experiments were conducted, which may have been a factor in this difference. It should be kept in mind that the non-irrigated plats did receive moisture as rainfall, which varied from 3.5 to 6.0 inches during the growing season, so that the differences are not as great between such plats as they might have been.

In the non-irrigated and irrigated plats at Laramie, scab in 3 of the 4 cases was considerably more prevalent in the dry than in the irrigated series.

However, in a series of fertilizer experiments conducted under both irrigated and non-irrigated conditions at Laramie during 1935 and 1936 the reverse was found to be true. In 1935, scab prevalence was significantly greater in the irrigated fertilizer plats than in the non-irrigated plats. Similarly, in 1936, scab was more prevalent in the irrigated series than in the non-irrigated ones, but it was significant in only 2 of the 13 plats. This inconsistency in scab prevalence under irrigated conditions between treatment-plats and fertilizer-plats may be because of a soil-reaction factor induced by the acid-producing fertilizers. In the non-irrigated plats, the fertilizer solution would be more concentrated, giving a more acid reaction (which would be more unfavorable to scab development) than that in the irrigated plats where the fertilizer solutions would become more diluted. On the whole, it seems that factors other than moisture have been important in producing scab.

THE RELATION OF MOISTURE TO RHIZOCTONIA PREVALENCE

Recently, Schaal (23) found that potatoes grown under heavy irrigation applications in Colorado had a higher per cent (30.4) of Rhizoctonia on the tubers than those grown with light or with no irrigations (both 3.0 per cent).

Results in the present study show that in 2 of the 3 years at Torrington, where this factor was tested, Rhizoctonia on the tubers was significantly more abundant in the irrigated than in the non-irrigated series. Similar results were found in an irrigation experiment conducted at Laramie in 1936. However, in the fertilizer experiments at Laramie during 1935 and 1936 previously mentioned, Rhizoctonia was significantly more abundant for both control- and fertilizer-plats in non-irrigated than in irrigated tests. This difference was especially great in 1936 where the odds for significance were 5000:1.

The time of applying irrigation water in regard to its effect on Rhizoctonia-sclerotial development on tubers is rather inconsistent. The 3-years results of this nature at Torrington show that, although the series irrigated regularly had more Rhizoctonia on the tubers than the non-irrigated plats, the plat irrigated regularly to mid-season and non-irrigated from then on, had the greatest average amount of Rhizoctonia, while the plat, at first dry and later irrigated, had scarcely more Rhizoctonia than the non-irrigated ones. In the light of these results, it appears that other factors may be more important than moisture in causing Rhizoctonia.

EFFECT OF MOISTURE APPLICATIONS ON YIELD

Although the study of moisture through irrigation water and yields is incidental to disease experiments, it was thought advisable to briefly present this material along with the other data accumulated from this study.

As before mentioned, the irrigation plats were divided into four equal parts as follows: (1) non-irrigated; (2) irrigated regularly 3 to 4 times to about mid-season and water withheld the latter part of the season; (3) water withheld the first part of the

season and applied regularly from then on, 3 to 4 applications; and (4) watered regularly throughout the season with 6 to 8 applications. The average yields in bushels per acre in healthy non-treated and total-treatment plats, respectively, in the above irrigation series, are as follows: (1) 128 and 103, (2) 215 and 165, (3) 180 and 155, and (4) 231 and 177. As an average of all plats, the yield was increased about 73 per cent in irrigated over non-irrigated plats.

RELATIVE YIELDING ABILITY OF HEALTHY, SCABBY AND RHIZOCTONIA LOTS OF POTATOES

It is a foregone conclusion that healthy seed will outyield diseased seed, other factors being equal. It may readily be seen that a disease such as Rhizoctonia, with its ability to attack and even kill underground plant parts, can reduce yields enormously. MacMillan and Christensen (16) stated that yields were higher for seed having light infection of Rhizoctonia than for that heavily infected. Common scab, because it does not attack underground parts, except the tubers, would not be expected to reduce yields proportionately. Goss and Werner (11) and Goss (10) found little evidence that scab had any effect upon yield.

In the present study, as an average of all plats where healthy, scabby, and Rhizoctonia lots of the same variety of non-treated seed was grown, and replicated four times, the yield of healthy seed was highest, averaging 176.9 bushels per acre. The Rhizoctonia lots were next, with 127.3, while scabby seed was lowest with 111.5 bushels per acre. In most cases, the yield differences between the three lots were significant, i.e., Rhizoctonia lots over scabby ones, and healthy lots over Rhizoctonia lots. Perhaps the severity of the scab on the seed was a factor in low yields, although the stands were practically as good as those from healthy seed. Also, the soils on which the experiments were conducted were largely of an alkaline nature and scab was more prevalent than Rhizoctonia.

RELATIVE SCAB PREVALENCE ON HEALTHY, SCABBY, AND RHIZOCTONIA LOTS OF SEED

Naturally, one would expect to find scab more prevalent in the crop planted with scabby seed than that planted with healthy or Rhizoctonia seed unless the soil is badly infested.

In the present studies, this was found in all cases except one, where scab prevalence in the crop was much higher in both healthy and Rhizoctonia lots of seed. In all cases, except this one, there was more scab on the crop from healthy seed than from Rhizoctonia seed. The average relative scab prevalence on healthy, Rhizoctonia, and scabby seed was 1.90, 1.65 and 2.82, respectively.

RELATIVE RHIZOCTONIA PREVALENCE ON HEALTHY, SCABBY AND RHIZOCTONIA LOTS OF SEED

Similarly, one would expect to find Rhizoctonia most prevalent on tubers grown from Rhizoctonia-infected seed, and less prevalent from healthy seed and scabby seed lots, unless the soil is badly infested by the causal fungus.

Brown (3) found "the average amount of Rhizoctonia for all treatments was less in the crop from the Rhizoctonia than from the scabby class of seed." In all cases in the present studies, Rhizoctonia was most prevalent in the crop from Rhizoctonia seed. Also, in all cases, there was more Rhizoctonia from scabby seed than from healthy seed. The average relative Rhizoctonia prevalence on healthy, scabby, and Rhizoctonia seed was 0.07, 0.23, and 0.43, respectively.

SOIL INFESTATION

When potatoes are grown year after year, or for a long period of time, the soil is likely to become heavily infested with organisms which cause plant disease. This is especially true of the scab and Rhizoctonia pathogens. The soil reaction is, no doubt, very important in the rate of increase of such organisms. It is generally considered that scab is favored by an alkaline soil reaction while

Rhizoctonia is favored by an acid soil reaction. Blodgett and Howe (2) found most scab in New York potato soils having a pH of 5.45 to 7.4, less scab in those from pH 7.5 to 8.5, and least scab in those from pH 4.3 to 5.4. Smith (24) working also in New York, reported similar findings. In Nebraska soils, Goss (10) found 68.4 per cent of scab at 5.9-6.5 pH, and 29.8 per cent at 8.0-8.3 soil pH. Blodgett and Howe (2) also mention that they found significantly more scab on lighter soils than on medium or heavy soils.

In the present studies, judging from the amount of disease on healthy treated seed planted in the various plats over the 5-year period, there was slight to considerable soil infestation by both scab and Rhizoctonia organisms. With one exception, (at Laramie in 1932, where scab infection was 100 per cent on harvested tubers) soil infestation was more prevalent at Torrington than on the other farms. Here there was more scab infection from the soil than there was Rhizoctonia infection, which was slight to practically none. At Archer soil infestation was very slight. At Laramie in 1936, soil infestation was also slight, but contrary to expectation, there was more Rhizoctonia than scab resulting from soil infestation. Clayton (6) stated, for New York conditions, that it is the soil and not the seed that is important in determining the amount of scab infection. Under such soil conditions seed treatments are useless and are not recommended.

SOIL TREATMENTS FOR THE CONTROL OF SCAB AND RHIZOCTONIA

Where soil infestation by disease organisms is a factor, benefits can sometimes be obtained by the use of certain materials applied to the soil. White (27) stated that scab from soil infestation has been lessened by green manure and sulfur applications. Frutchey and Muncie (9) found that yellow oxide of mercury, calomel and organic mercury compounds were not effective as soil treatments in the control of scab. In some of the eastern states, in particular, sulfur is applied to certain soils for the control of potato scab. Vaughan and Brann (26) state that sulfate of ammonia as a source of nitrogen is also a help in reducing losses from scab in Wisconsin.

In preliminary fertilizer experiments at Laramie in 1935 previously mentioned, inoculated sulfur, sulfur plus well-rotted sheep manure, and ammonium sulfate were used as soil treatments in four different rates of applications: 200, 400, 800, and 1600 pounds per acre. The irrigation was also varied, one-half receiving one irrigation (early) and the other half, three irrigations. Inoculated sulfur and ammonium sulfate in the plot receiving irrigations, gave some indication of scab control.

A similar experiment was conducted in 1936, using inoculated sulfur, superphosphate and ammonium sulfate, each at the rate of 200 and 400 pounds per acre, and in eight replications. Four replications of each were irrigated three times and four with only one irrigation, that one early, to insure a good stand. In scab prevalence, all three soil treatments were significantly better than the checks, or nearly so. The ammonium sulfate was best in this respect, although no one fertilizer was significantly better than the others. In the irrigated series, however, the differences were small, and only slightly better than the controls.

From the standpoint of *Rhizoctonia*, no soil treatment in the irrigated series was significantly better than the controls. In the dry series, only ammonium sulfate gave significantly better results than the controls or than either of the other two treatments.

Unfortunately the best control of both scab and *Rhizoctonia* was found in the dry, rather than in the irrigated series, for it is doubtful if a fertilizer application would be practical under dry conditions, whereas, it might be practical under irrigation.

SUMMARY

Seed treatment experiments were conducted during the years 1932 to 1936 at Archer, Torrington, and Laramie. Rhizoctonia and scabby lots of Bliss Triumph and Cobbler seed were treated with the following materials: Hot formaldehyde, acid-formaldehyde, formaldehyde dust, sulfur dust, mercuric chloride or corrosive sublimate, acid-mercury, Mercurnol, and Semesan Bel.

A single index figure was calculated for each treatment to show the relative amount of Rhizoctonia and scab on the tubers.

Acid-mercury was the only treatment which increased the stand above that of the controls, and formaldehyde dust gave the poorest results of any of the treatments. In most cases, the differences in stand from the various treatments were not significant.

In size and uniformity of plants, acid-mercury ranked first and acid-formaldehyde last of the treatments used. However, the differences were small and it is doubtful if they are significant. Similarly, in vigor of plants no one treatment was consistently better than the others.

None of the treatments used on healthy seed increased yields significantly above the control plats. However, with Rhizoctonia-lots of seed, certain treatments have, in all cases but one, significantly increased yields over the controls. With scabby seed, none of the treatments increased the yield significantly over the controls, except in one case.

As an average of all yields in all experiments, the treatments ranked in the following order: Mercuric chloride, acid-mercury, Semesan Bel, Mercurnol, acid-formaldehyde, hot formaldehyde and formaldehyde dust. The two latter treatments decreased yields considerably as compared to the controls, all others showed increases.

For effectiveness against scab, no one treatment was consistently better than the others. On healthy, scabby, and Rhizoctonia-lots of seed for the 5-year test, they may be ranked as follows in their ability to control scab: Acid-formaldehyde, hot formaldehyde, formaldehyde dust, acid-mercury, mercuric chloride, Mer-

curnol, and Semesan Bel. All treatments gave some degree of scab control.

As evidenced by stem lesions on the plants, acid-mercury was slightly more effective for *Rhizoctonia* control than was corrosive sublimate. For all experiments on healthy, scabby, and *Rhizoctonia* seed, the treatments ranked in the following order in *Rhizoctonia* control: Acid-mercury, mercuric chloride, acid-formaldehyde, formaldehyde dust, Mercurnol, Semesan Bel, and hot formaldehyde. The controls had considerably more scab than did any of the treatment-lots. Although the average differences between treatments were small, the better treatments are significantly better than the poorer ones in a number of cases.

In percentage of disease-free tubers from healthy lots of seed, no treatment was consistently best. With *Rhizoctonia*-lots, however, acid-mercury was the best treatment, while with scabby seed, it equalled hot formaldehyde in effectiveness.

As an average of all treatments on all seed, the treatments ranked in the following order for per cent of disease-free tubers (from best to poorest): Mercuric chloride, acid-formaldehyde, acid-mercury, Mercurnol, hot formaldehyde, Semesan Bel, and formaldehyde dust. All treatments were considerably above the controls.

Pre-sprinkling of seed, although tried but one year, gave favorable results in stand, yield, and percentage of disease-free tubers. Where tubers are heavily infected with scab, and especially *Rhizoctonia*, pre-sprinkling should render the treatment more effective.

Although dusts were used only in a limited way, they were not as effective in controlling disease nor as practical for use as were liquids.

Some of the newer short-time treatments were used in these studies for comparison with the standard treatments. One of the most promising of these was acid-mercury which was as good, if not better than mercuric chloride for both scab and *Rhizoctonia* control. However, it is more efficient for *Rhizoctonia* than it is for scab. In addition, it is safe and easy to use and requires only

5 to 10 minutes treating time. Mercunol, the commercial acid-mercury compound, was used in comparative tests with acid-mercury for only one year. Neither was consistently better than the other, although, in general, acid-mercury was slightly better in the one-year tests. However, Mercunol has the advantage of being prepared ready to use, except for proper diluting.

Semesan Bel increased yields over checks in some cases and reduced them in others. It was most consistent with Rhizoctonia lots of seed, increasing them in 3 of 4 trials, once significantly. It, however, was surpassed by both mercuric chloride and acid-mercury from the standpoint of yield. It was about as effective for scab as for Rhizoctonia control, although for all tests, it was less effective for both scab and Rhizoctonia under heavy infection, than most of the other treatments. However, where potatoes are only slightly diseased, Semesan Bell will probably give satisfactory results.

Acid-formaldehyde, although not used commercially, was found to be even better than hot formaldehyde from the standpoint of yield, scab and Rhizoctonia control, and especially in the percentage of disease-free tubers. As with hot formaldehyde, it is more efficient for scab control than for Rhizoctonia control, although it was surpassed only by acid-mercury and mercuric chloride in Rhizoctonia control.

The amount of scab developing under different soil-moisture conditions during the 5-year period has not been consistent, although on the average there was more in the non-irrigated plats than in the irrigated ones. In fertilizer plats, however, the reverse is true, possibly because of a soil-reaction factor induced by the acid-producing fertilizers.

In 2 of 3 year's tests at Torrington, Rhizoctonia prevalence was significantly greater in irrigated plats than in non-irrigated ones. However, in fertilizer tests at Laramie during 1935 and 1936, Rhizoctonia prevalence was significantly greater in the non-irrigated than in the irrigated series, both in the controls and in the treatment plats.

As a result of the 3-year irrigation tests at the Torrington station, all treatment-plats in the irrigated series yielded, on the average, 73 per cent more than similar plats in non-irrigated series.

As an average of all plats, healthy seed yielded 176.9 bushels per acre, Rhizoctonia seed 127.3 bushels, and scabby seed 111.5 bushels per acre.

The relative scab prevalence on healthy, Rhizoctonia and scabby seed averaged 1.90, 1.65, and 2.82, respectively.

The relative Rhizoctonia prevalence on healthy, scabby and Rhizoctonia seed averaged 0.07, 0.23, and 0.43, respectively.

Soil infestation by scab and Rhizoctonia organisms was found to be of slight to considerable importance in the experiments conducted during the 5-year period.

Treatments of inoculated sulfur, ammonium sulfate, superphosphate, and other fertilizers applied to the soil, under both non-irrigated and irrigated conditions, were not generally effective in controlling diseases. Ammonium sulfate gave some reduction of scab in the non-irrigated plats.

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